New Millennium Program

Space Technology 6 (ST 6)

Subsystem Space Flight Validation Opportunity

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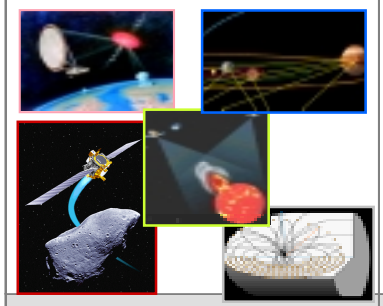
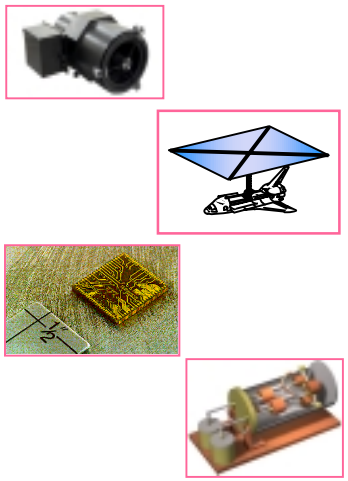
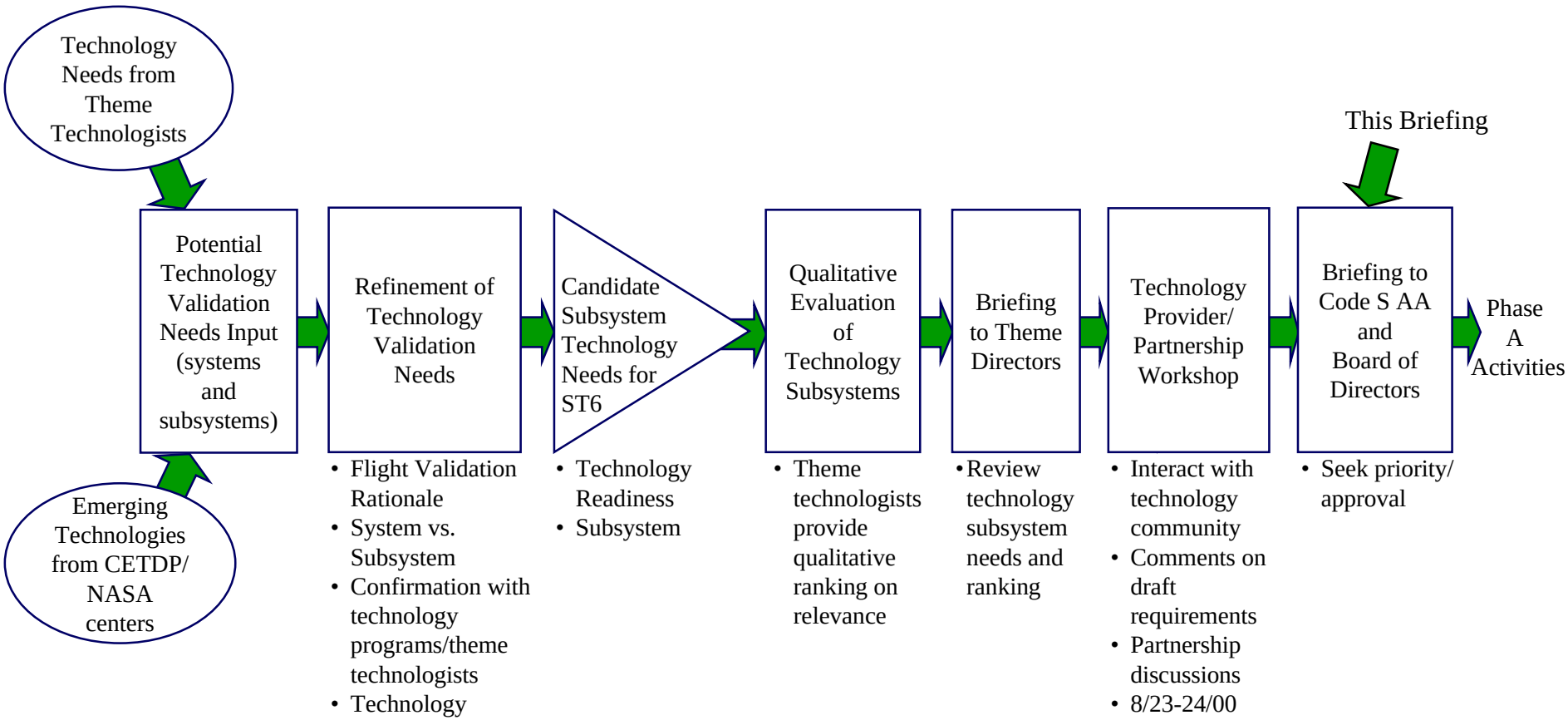
August 23, 2000

Introduction
Revamped New Millennium Program Structure

- Revamped New Millennium Program structure discussed in March through September'99

	Approach	Project Attributes
System Validation 	Suites of new technologies to enable new system capabilities by performing critical system-level functions in a flight validation project	• Balanced mix of small and medium projects – Small (the normal): $50M class project with shared launches – Medium (occasional): $100-$150M class project • Yearly launches of system validation project
Subsystem Validation 	**Subsets or components of systems are flight validated as "stand-alone" technology subsystems on flights of opportunity and NMP technology carriers**	• **Yearly flight opportunities for several subsystems as technology items on flights of opportunities or technology carrier** • **$25M class technology subsystem projects (multiple subsystem items per project)** • **Partnership for flights of opportunity** • **NASA hosts technology carrier every 3 years** **- $15M-class carrier plus launch**

Subsystem Technology Validation Needs Identification/Evaluation

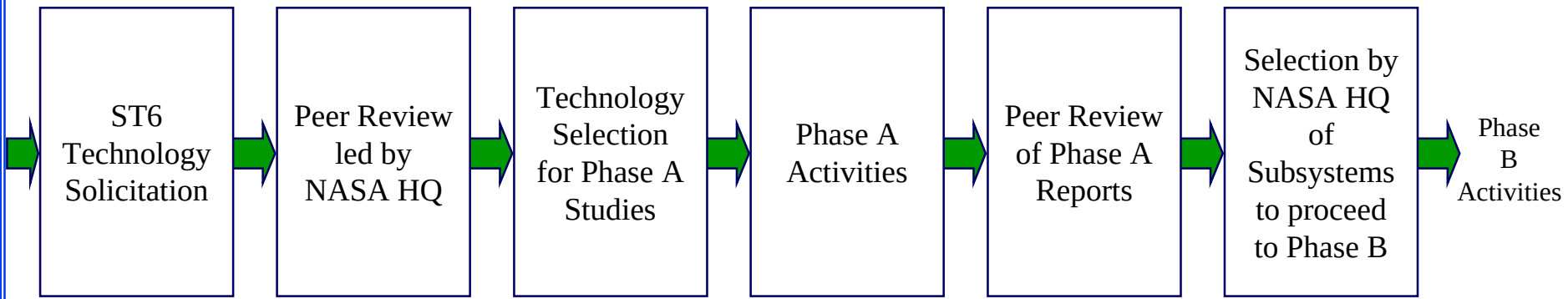


Flight Validation Criteria

FACTORS	SUB-FACTORS	EXAMPLE EFFECTS	EXAMPLE JUSTIFICATION
1. MAJOR IMPLEMENTATION SHIFT **(Never Flown Before)**	1.1 **Fundamental Change** is a revolutionary way of designing, assembling, fabricating, testing, integrating, or operating.	Revolution in Design Procedures or Operations.	Multifunctional structures invoke new assembly, test and rework procedures that depart from existing practice and require flight validation to verify procedures and demonstrate flight worthiness.
	1.2 **Combined Effects** are complex interactions between advanced technology and different parts of the system or launch vehicle.	Contamination, Noise Sources, Survivability, Ionic Contamination, Launch Debris.	Contamination, deposited by thrusters or other sources, is difficult to predict; thus, flight validation needed to confirm contamination models.
2. SPACE ENVIRONMENT **(Ground Test Inadequate)**	2.1 **Persistent Effects** are steady space/planetary environments acting on the technology.	Zero Gravity, Radiation Effects, Noise Sources, Temperature cycling.	Large, light-weight deployable structures need zero G flight validation because an accurate ground test is impossible.
	2.2 **Transient Effects** are impulse space/planetary environments acting on technology.	Cosmic Rays, Temperature spike, Particle and Fields, Noise, Microphonics	System level faults, such as cosmic-ray induced single-event upsets in integrated circuits. Validation flight needed to confirm software error handlers.
	2.3 **External Interactions** are environments used by the technology to accomplish something.	Cometary Surfaces, Planetary Atmospheres, Solar Wind.	Aeroassist technologies using planetary atmospheres and solar sails using solar wind for propulsion. Both require flight validation to build an experience base and to determine the performance envelope and operating safety margins.
	2.4 **Reliability Hazards** are space/planetary environments that degrade performance.	Micrometeorite, Dust Accumulation, Atomic Oxygen, Radiation Effects.	Micrometeorite, orbital debris, dust accumulation, atomic oxygen, and radiation effects are difficult to predict and simulate.

Subsystem Technology Solicitation/ Phase A Activities

- ST6 planned to be ~$25M*
- Plan to solicit ~6-8 items for Phase A (average ~$500K/item Phase A studies)
- Expect to select ~3-5 items for Phase B/Implementation



- Annoucement Late Sept'00
- Proposals due mid Nov'00

- Nov'00-Jan'01

- Feb'01

- Demonstrate that technology is at TRL" 4
- Develop technology validation experiment plan for Phase B/C/D/E activities
- Identify access to space
- Prepare six-month study report

- 08/01

- 08/01

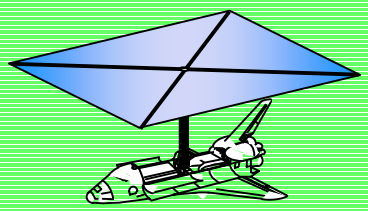
** Cost includes technology development, integration/test, technology validation and reporting. Cose does NOT include access-to-space.*

Technology Solicitation Preliminary Evaluation Criteria

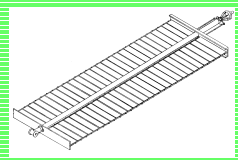
- Applicability to NMP technology requirements
- Maturity of the technology
- Capabilities of the provider organization
- Management, cost, schedule and implementation approach
- Viability of proposed partnerships and method for access to space

Candidate Technology Subsystem Areas for ST6

Lightweight Deployables

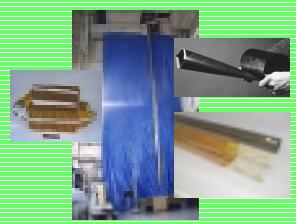


Solar Sail Deployment



Lightweight High Voltage Solar Array

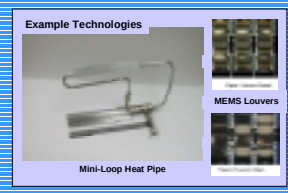
Membrane Optics Deployment



Deployable Booms

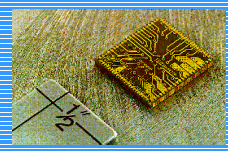
Spacecraft Miniaturization

Wideband Optical Communications



Miniature Integrated Thermal Energy Management

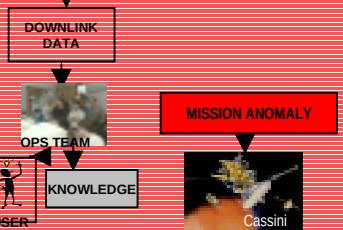
Secondary Batteries for Deep Space Missions



Ultra Low Power Electronics

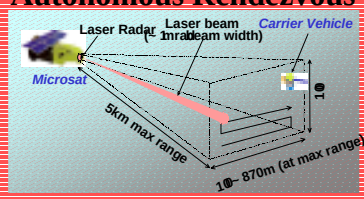
Autonomy

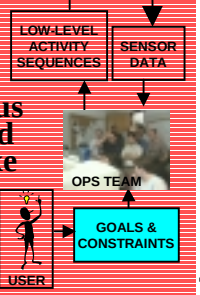
Onboard Data Processing



Model-based Fault Protection

Autonomous Rendezvous

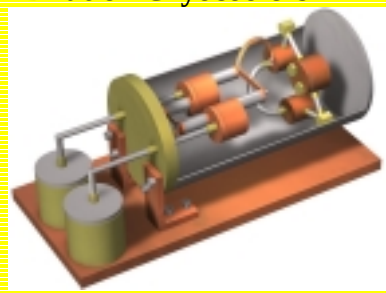




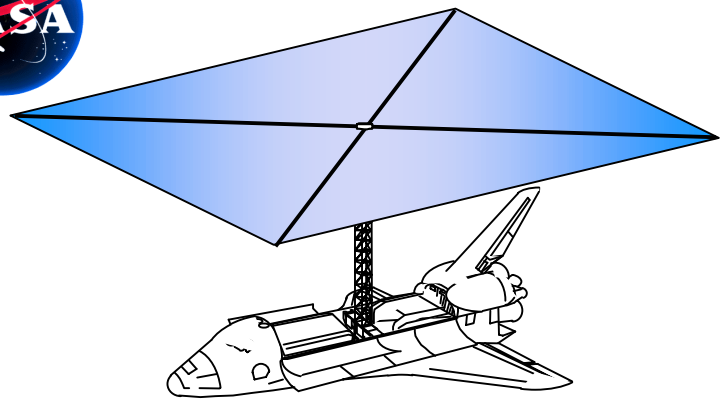
Autonomous Goal-based Cmd & Exe

Cryogenics

Dilution Cryocoolers



Solar Sail Deployment



Characterization of Sail Deployment Structural Dynamics

Technology Requirements:

- Deploy 40m x 40m sail
- Areal density 10-15 g/m2
- Experiment mass < 150kg

Potential Missions:

- **ESS: NO**
- **SEC: SPI, ISP (GSRI, Sub-L_1S, PASO, SF, IHC, OHRI, ISTB)**

State of the Art:

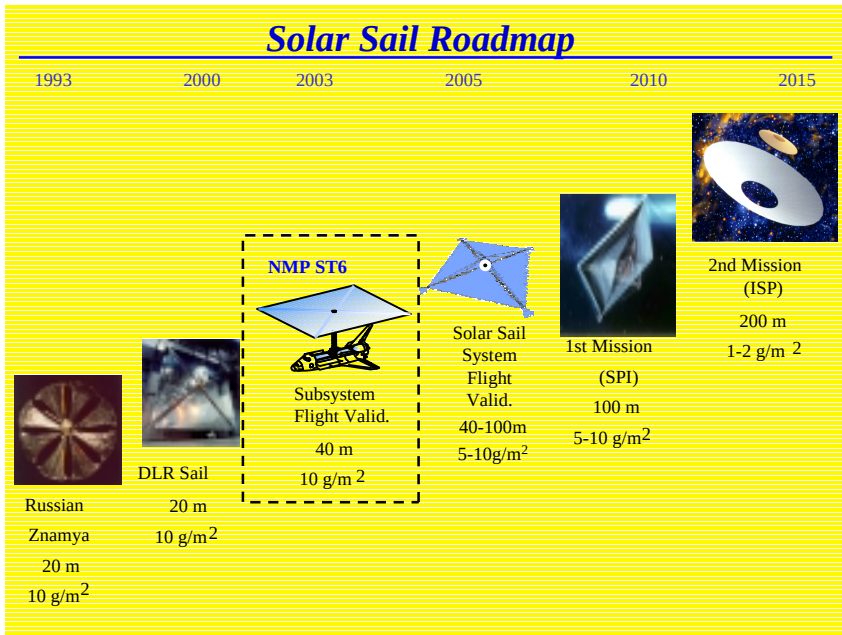
- Russia has deployed 20m sail
- DLR has developed prototype 20m x 20m sail

Flight Validation Rationale:

- Reduce risk for future sail missions by demonstrating deployment of large sail in microgravity environment.
- Microgravity deployment dynamics cannot be simulated in ground testing.
- Characterize structural dynamics of deployed sail to validate analytical models developed in ground testing.
- Assess the combined effects of the space environment on sail shape. Environmental effects include solar radiation pressure, microgravity, static charging, and thermal deformations.

Preliminary Cost Range/Validation Concept:

- $6M - $8M
- Shuttle Hitchhiker attached payload



Potential Mission Support by Candidate Technologies

Technology Candidate	Near/Mid-term	Far-term
Solar Sail Deployment	SPI(1), NO(2)	ISP(1), (GSRI[1], SUB-L_1S[1], PASA [1], SF[1], IHC[1], OHRI[1], ISTB[1])
Lightweight High Voltage Solar Array	CNSR(2), NO(2), SRO(2)	ISP(1), TE(2),VSSR(2)
Deployable Booms	GEC (1), RAM(1), SPI(1), NO(2), ARISE(3), CON-X(3), OWL(3), SPIRIT(3), TPF(4)	ISP(1), FAIR (4), LF(4), SUVO(4), (GSRI[1]),
Membrane Optics Deployment	CON-X(3), HSI(3), SPIRIT(3)	MAX IMPF(3), FAIR (4), LF(4)
Ultra Low Power Electronics	GEC(1), MC(1), CNSR(2), EL(2), MSR(2) NO(2), SRO(2)	SN(1), TE(2),VSSR(2)
Miniature Thermal Control Subsystem	CNSR(2), NO(2)	TE(2)
Optical Wideband Communications	CNSR(2), EL(2), NO(2), SRO(2), ARISE(3)	ISP(1), VSSR(2)
Secondary Batteries	Deep Space Missions	Deep Space Missions
Autonomous Rendezvous	CNSR(2), EL(2), MSR(2), Potential TPF(4)	VSSR(2)
On-board Data Processing	RAM (1), SDO(1), GEC(1), MC(1), MMS(1),RAM (1), CNSR(2), EL(2), NO(2), SRO(2), ARISE(3), CON-X(3), OWL(3)	ISP(1), TE(2),VSSR(2)
Goal-based Commanding & Execution	CNSR(2), EL(2), NO(2), SRO(2), OWL(3)	ISP(1), TE(2), VSSR(2), MAX IMPF(3)
Model-based Fault Protection	RAM (1), SDO(1), CNSR(2), EL(2), NO(2), SRO(2), ARISE(3), CON-X(3), OWL(3)	ISP(1), TE(2),VSSR(2)

Summary

- Purpose of Workshop Breakout Sessions
  - Derive better understanding of technology requirements
  - Explore broad range of technology solutions for meeting requirements
  - Develop accurate assessments of technology maturity for high-value technologies
  - Define technology-specific requirements for space flight validation
  - Define platform accommodation requirements for technologies
  - Identify potential for partnerships (technology development/access to space)

- Output of Workshop to be used to focus Technology Solicitation

Mission Acronym List

Acronym	Mission	Time Frame	Status	Theme
ACT	Advanced Compton Telescope	Far Term	Roadmapped by Theme Only	SEU
ARISE	Advanced Radio Interferometry between Space and Earth	Mid Term	In Strategic Plan	SEU
CNSR	Comet Nucleus Sample Return	Mid Term	In Strategic Plan	ESS
Con-X	Constellation-X	Mid Term	In Strategic Plan	SEU
EL	Europa Lander	Mid Term	In Strategic Plan	ESS
FAIR	Filled Aperture Infrared (Capability Concept)	Far Term	In Strategic Plan	ASO
GEC	Geospace Electrodynamic Connections	Near Term	In Strategic Plan	SEC
GSRI	Geospace System Response Imager	Far Term	In Strategic Plan	SEC
HSI	High Resolution Spectroscopy Mission	Mid Term	In Strategic Plan	SEU
IHC	Interheliospheric Constellation	Far Term	Roadmapped by Theme Only	SEC
ISP	Interstellar Probe	Mid Term	In Strategic Plan	SEC
ISTB	Intersteller Trail Blazer	Mid Term	In Strategic Plan	SEC
ITM Waves	Ionosphere-Thermosphere-Mesosphere Waves Probe	Mid Term	In Strategic Plan	SEC
LF	Life Finder	Far Term	In Strategic Plan	ASO
MAXIM	MicroArcsecond X-ray Imaging Mission (/Pathfinder)	Far Term/ Mid Term	In Strategic Plan	SEU
MC	Magnetospheric Constellation	Mid Term	In Strategic Plan	SEC
MMS	Magnetoperic Multiscale	Mid Term	In Strategic Plan	SEC
MSR	Mars Sample Return	Mid Term	In Strategic Plan	ESS
NGST	Next Generation Space Telescope	Mid Term	In Strategic Plan	ASO
NO	Neptune Orbiter	Mid Term	In Strategic Plan	ESS

Mission Acronym List
(cont'd)

Acronym	Mission	Time Frame	Status	Theme
OHRI	Outerheliospheric Radio Imager	Far Term	Roadmapped by Theme Only	SEC
OWL	Orbiting Array of Wide-angle Light Collectors	Mid Term	In Strategic Plan	SEU
PASO	Particle Acceleration Solar Orbiter	Far Term	Roadmapped by Theme Only	SEC
RAM	Reconnection and Multiscale Probe	Mid Term	In Strategic Plan	SEU
RBM	Radiation Belt Mappers	Far Term	In Strategic Plan	SEC
SDO	Solar Dynamics Observatory	Near Term	In Strategic Plan	SEU
SN	Sentinels	Far Term	Roadmapped by Theme Only	SEC
SF	Solar Flotilla	Far Term	Roadmapped by Theme Only	SEC
SP	Solar Probe	Near Term	In Strategic Plan	SEU
SPECS	Submillimeter Probe of the Evolution of Cosmic Structure	Far Term	Roadmapped by Theme Only	SEU
SPI	Solar Polar Imager	Mid Term	In Strategic Plan	SEU
SPIRIT	Space InfraRed Interferometric Telescope	Mid Term	In Strategic Plan	SEU
SRO	Saturn Ring Observer	Mid Term	In Strategic Plan	ESS
SISP	Stellar Imager and Seismic Probe	Far Term	Roadmapped by Theme Only	SEC
SubL_1S	Sub-L_1 Sentinal	Far Term	Roadmapped by Theme Only	SEC
SUVO	Space Ultraviolet Observatory (Capability concept)	Far Term	In Strategic Plan	ASO
TE	Titan Organic Explorer	Far Term	In Strategic Plan	ESS
TPF	Terrestrial Planet Finder	Near Term	In Strategic Plan	ASO
VSSR	Venus Surface Sample Return	Mid Term	In Strategic Plan	ESS